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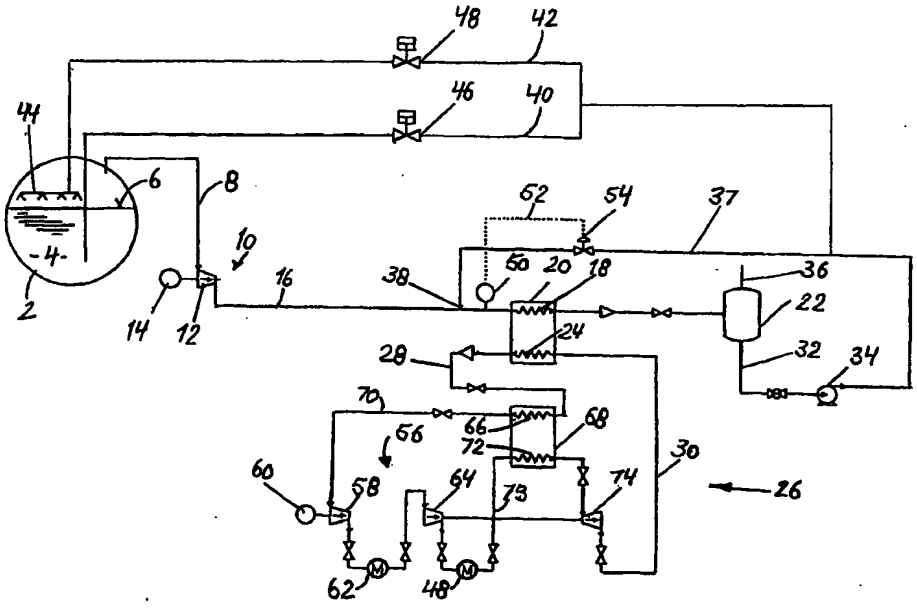

(57) Abstract

A method for storage and transport of liquefied natural gas (LNG), substantially comprising nitrogen and methane, in a tank (2) wherein LNG decoction is obtained. The decoction is taken from the tank (2) and the pressure of the decoction is increased, whereupon the decoction is cooled in a cooler (20) to a temperature of between the condensation temperature for the methane and the nitrogen. Only condensed methane is returned to the tank (2). A device for implementation of the method.

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Method and device for storage and transport of liquefied natural gas

The invention relates to a method for storage and transport of liquefied natural gas, hereinafter called LNG, comprising nitrogen and other gases, principally methane and hereinafter called methane, in a tank wherein the LNG boils and LNG in a gaseous state is obtained, hereinafter called decoction.

The invention further relates to a device for implementation of this method.

During storage and transport of LNG (Liquefied Natural Gas) at a pressure approximately corresponding to the pressure of the ambient atmosphere, a portion of this LNG will boil off and be converted to gas.

In ships which transport LNG, the decoction is used as fuel for propulsion of the ship, since a more economical alternative has not yet been found for this kind of transport. This, however, results in relatively expensive running of the ship, since the gas is used for production of steam and operation of steam turbines, whose efficiency is lower than, e.g., diesel motors for running ships.

There is also the commonplace solution of re-liquefying the natural gas and introducing it into the tank. This, however, is very energy-demanding.

The object of the invention is to provide a method and a device of the above-mentioned type for reduction of the costs of storage and transport of liquefied natural gas.

The characteristic of the method and the device according to the invention is presented in the characteristic features stated in the claims.

The invention will now be described in more detail with reference to the drawing whose single figure is a pipe diagram which schematically illustrates an embodiment of a system or plant for storage or transport of LNG with a device according to the invention.

As illustrated in the figure, the system comprises a tank 2 containing LNG 4 whose surface is indicated by the reference numeral 6. The tank space over this surface 6 communicates via a pipeline 8 with the inlet of a first compressor device 10 comprising a first compressor 12 which is driven by a motor 14.

The outlet of the compressor device 10 communicates via a pipeline 16 with the inlet of a first passage 18 of a first cooler or heat exchanger 20, the outlet of this passage 18 communicating with an inlet of a liquid/gas separator 22.

In the cooler 20 there is provided a second passage 24, whose inlet is supplied with a cooled coolant from a standard per se cooling plant 26 via a pipeline 30, and whose outlet returns heated coolant to the cooling plant 26 via a pipe 28.

The outlet of the liquid/gas separator 22 from which separated liquid can flow, is connected via a pipeline 32 to an inlet of a pump 34. Separated gas can flow from the separator 22 to the ambient atmosphere via a pipeline 36.

An outlet of the pump 34 communicates via
- a pipeline 37 with the pipeline 16 at a lead-in point 38 thereof,
- a pipeline 40 with the tank space under the LNG surface in the tank 2, and
- a pipeline 42 with the space over the LNG surface in the tank 2.

The pipeline 42 may be terminated by a nozzle device 44 in the tank 2.

In the pipelines 40, 42 there may be provided respective shut-off valves 46 and 48.

Between the lead-in point 38 and the inlet of the first passage 18 of the cooler 20, there may be connected to the pipeline 16 a temperature sensor 50 which may be connected via an electric cable 52 to an electrically operated shut-off valve 54.

The cooling plant 26 is of a known per se type and includes a second compressor device 56 comprising a second compressor 58 which is driven by a motor 60. On the downstream side of the second compressor 56 there is provided an intermediate cooler 62 on whose downstream side there is provided a third compressor 64.

The inlet of the second compressor 58 communicates with the outlet of a third passage 66 of a second cooler or heat exchanger 68 via a pipeline 70. The outlet of the second compressor device 58 communicates with the inlet of a fourth passage 72 of the second heat exchanger 68 via a pipeline 73, and the outlet of the fourth passage 72 communicates with the inlet of an expansion turbine 74, whose outlet is connected to the inlet of the second

passage 24 of the first heat exchanger 20 via the pipeline 30. The third compressor 64 is driven by the expansion turbine 74.

The device works as follows.

Decoction in the tank 2 flows via the pipeline 8 to the first compressor device 10, where it is compressed and thereby greatly overheated. From this compressor device 10 the decoction flows through the first passage 18 of the first heat exchanger 20 and is cooled to a temperature of between the condensation temperature for methane and the condensation temperature for nitrogen. A mixture of liquid and gas thereby flows to the separator 22 where the liquid methane is separated from the nitrogen gas which flows out into the atmosphere via the pipeline 36.

If the shut-off valve 46 is open, a first portion of the liquid methane is returned via the pipeline 40 to the tank 2 under the LNG surface level. If the shut-off valve 48 is open a second portion of the liquid methane is returned via the pipeline 42 to the tank 2 and sprayed into the decoction, i.e. over the LNG surface 6, via the nozzle device 44, thus cooling the decoction, with the result that a portion thereof may be condensed in the tank or the decoction is at least reduced.

When transporting LNG in full tanks in ships, the shut-off valve 48 will normally be closed and the shut-off valve 46 will be open. However, any combination of positions of the shut-off valves 46, 48 and 54 is possible.

If the temperature of the decoction in the pipe 16 between the first compressor device 10 and the first heat exchanger 20 exceeds a certain threshold value, a signal is transmitted from the temperature sensor 50 to the shut-off valve 54 for opening thereof. This may occur especially if there is not much LNG in the tank and thus very little decoction. In this case the operating condition of the first compressor device is not optimal, with the result that its efficiency is reduced and the temperature of the compressed decoction is relatively high. In this case a third portion of the liquid methane is supplied to the pipeline 16 via the lead-in point 38, thus enabling the temperature of the decoction flowing into the first heat exchanger 20 to be reduced to such an extent that this heat exchanger can thereby be capable of providing the remaining cooling of the decoction to the temperature required therefor.

When returning the third portion of the methane, the result may also be achieved of reducing the temperature of the decoction which is supplied to the first heat exchanger 20 to such an extent that the heat exchanger's components may be cheaply manufactured from aluminium in the normal manner.

With a complete condensation of all the decoction, an energy-recovery efficiency of approximately 20% can be achieved. With only partial condensation of the decoction, i.e. only condensation of the methane and release of nitrogen in a gaseous state to the atmosphere or air according to the invention, an efficiency of this kind of approximately 38% can be achieved.

A person skilled in the art will understand that if the first heat exchanger and the separator are arranged at a higher level than the tank, liquefied methane will be able to flow back to the tank due to gravity. On the other hand there is a need for a pump to return liquefied methane to the return point in front of the inlet of the first cooler 20.

Furthermore, a person skilled in the art will understand that the compressor devices in the device according to the invention may include more compressors which are interconnected in series and between which intermediate coolers may be provided. It will also be understood that the device according to the invention may comprise further, known per se components of standard pipe arrangements, such as shut-off valves, check valves etc. which can be connected between the above-mentioned components of the device to enable it to work in the above-mentioned manner.

PATENT CLAIMS

1. A method for storage and transport of liquefied natural gas, hereinafter called LNG, comprising nitrogen and other gases, principally methane and hereinafter called methane, in a tank (2) wherein the LNG boils and LNG in a gaseous state is obtained, hereinafter called decoction, and the decoction is taken from the tank (2) and the pressure of the decoction is increased, characterized in that
- the decoction with the increased pressure is cooled in a cooler (20) to a temperature of between the condensation temperature for the compressed methane and nitrogen, and
- condensed methane is returned to the tank (2).

2. A method according to claim 1,
characterized in that a portion of the condensed methane is conveyed into the decoction whose pressure has been increased, but not yet cooled in the cooler (20).

3. A method according to claim 1 or 2,
characterized in that nitrogen which has been cooled in the cooler (20), but which has not been liquefied, is released into the atmosphere.

4. A device for implementation of the method which is indicated in claim 1, for storage and transport of liquefied natural gas, hereinafter called LNG, comprising nitrogen and other gases, hereinafter called methane, in a tank (2), wherein the LNG boils and LNG in a gaseous state is obtained, hereinafter called decoction, comprising a first compressor device (10) for compression of decoction from the tank (2),
characterized in that the device comprises
- a condensation device with a cooler (20), whose inlet is connected to an outlet of the first compressor device (10), and which is arranged for cooling of the compressed decoction to a temperature of between the condensation temperature for the compressed methane and nitrogen, and a separator, which is arranged for separation of nitrogen in a gaseous state from condensed methane, and
- a first piping arrangement (40, 42, 44, 46, 48) for returning condensed methane to the tank (2).

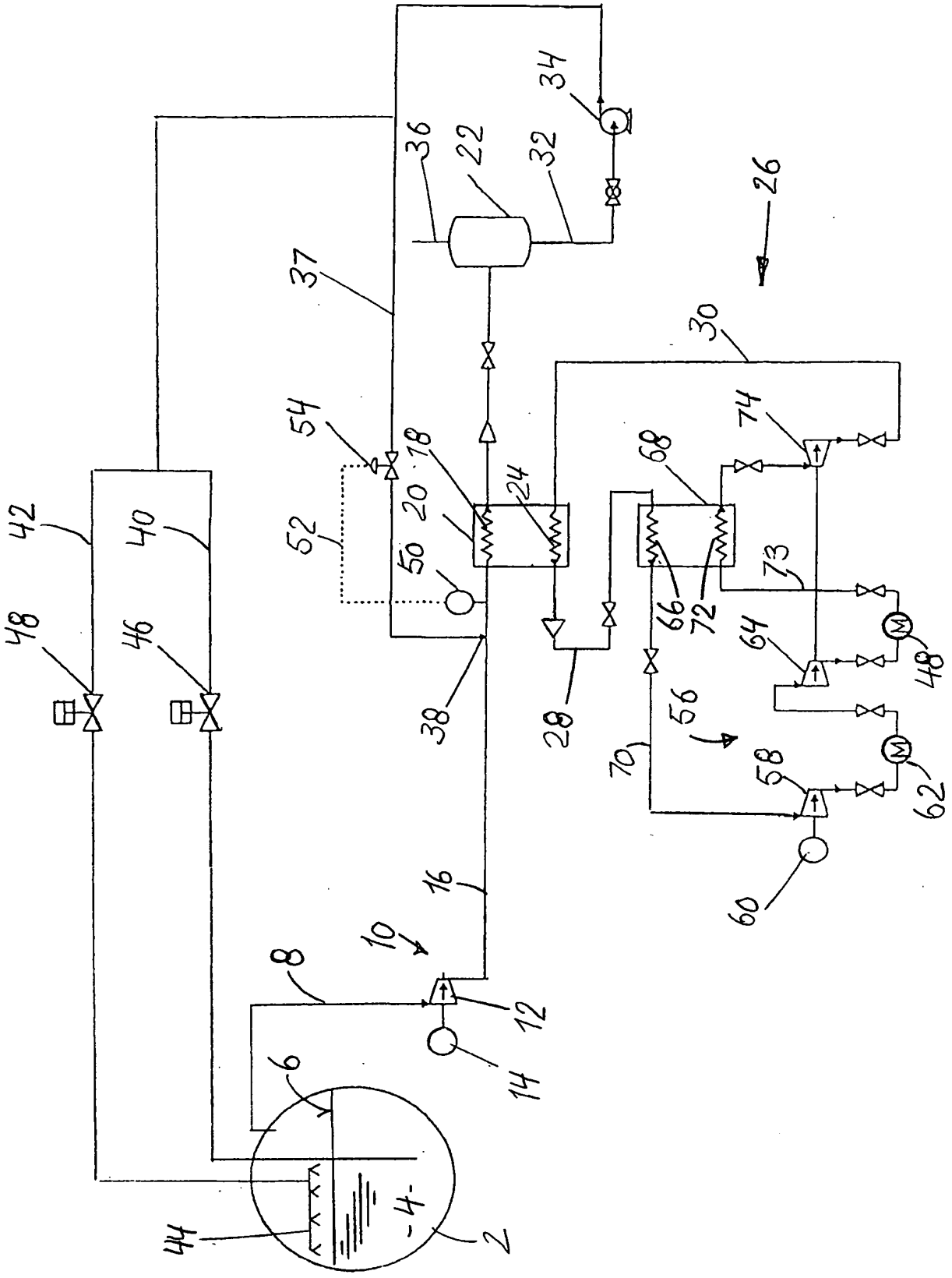
5. A device according to claim 4,
characterized in that it comprises a pump (34) for pumping condensed methane from the separator (22) to the first piping arrangement.

6. A device according to claim 4,
characterized in that it comprises a pump (34) for pumping condensed methane from the separator (22) to a second piping arrangement for conveying condensed methane to a lead-in point (38) on the upstream side of the cooler's (20) inlet.

7. A device according to claim 6,
characterized in that the second piping arrangement comprises a temperature sensor (50) which is arranged between the lead-in point (38) and the cooler's (20) inlet, a pipeline (37) which connects the pump to the lead-in point, and a first shut-off valve (54), which is provided in the pipeline (37) and controlled by the temperature sensor (50).

8. A device according to one of the preceding claims,
characterized in that the first piping arrangement comprises a first pipeline (42) which is terminated in the tank with a nozzle device (44) which is provided in the upper part of the tank (2).

9. A device according to one of the preceding claims,
characterized in that the first piping arrangement comprises a second pipeline (40) which is terminated in the tank (2) at the bottom thereof.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INTERNATIONAL SEARCH REPORT

International application No.
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A. CLASSIFICATION OF SUBJECT MATTER

IPC6: F25J 3/06, F17C 7/02, B63J 2/14
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: B63J, F17C, F25J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

QUESTEL: WPIL

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2783624 A (W.L. MORRISON), 5 March 1957 (05.03.57), column 2, line 44 - line 70, figure 1, claim 1 --	1-9
A	US 4675037 A (CHARLES L. NEWTON), 23 June 1987 (23.06.87), column 3, line 45 - line 62, figure 2 --	1-9

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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Information on patent family members

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